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The Sweet-Potato Weevil and its Control

C. M. Stewart

IMMENSE LOSSES of sweet potatoes in the Gulf States are being caused by the sweet-potato weevil. This foreign pest, introduced into the United States years ago, has become very destructive recently and now threatens to invade all States in which sweet potatoes are grown.

The slender, metallic-blue weevil, about a quarter of an inch long with red legs and "waist," attacks leaves, stems, and roots or "tubers," and its whitish larvæ or grubs tunnel the stalks and roots and inflict great damage, both in the field and in storage. Owing to the increased production of the sweet-potato crop to meet war conditions, this weevil has become a pest of the greatest importance. Indeed, it is to the sweet-potato industry what the boll weevil is to cotton.

This bulletin describes the insect and its injuries and gives a sufficient account of its life history to explain the control measures advised. The weevil can be stamped out in limited regions where it has not yet secured a firm foothold, and then, by quarantines, it can be kept out of States and parts of States not yet infested. It is vitally important at present to combat, by every means available, an insect that threatens to destroy our second most valuable vegetable crop.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief
Washington, D. C. January, 1919

THE SWEET-POTATO WEEVIL[1] AND ITS CONTROL.

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MENACE OF THE SWEET-POTATO WEEVIL.

THE growing of sweet potatoes has become one of our most important food-producing industries. Indeed, the sweet potato now ranks second as a vegetable in the United States, the value of the crop of 1917 having reached the hitherto unparalleled sum of $90,000,000 and that of 1918 being estimated at $116,867,000.

This industry is threatened by the ravages of an imported insect known as the sweet-potato weevil (fig. 1), which in the last few years has destroyed the sweet-potato crop more completely in the States where it is present than during all previous years. It has become permanently established in Texas, Louisiana, and Florida, and practically all directors, entomologists, and other agricultural officials of the Southern States have communicated with the Department of Agriculture regarding means of controlling it, and specific action has been taken by these States looking toward its eradication by quarantine measures against the infested regions.

In six States of the Union (fig. 4), in our insular possessions, and in foreign countries where the sweet-potato weevil has been reported as a pest,[2] its ravages have been severe; indeed, losses of from 25 to 50 per cent are commonly sustained, and not infrequently crops suffer so seriously from the attacks of this weevil as to be practically destroyed, the sound roots remaining being too few to justify harvesting. As a result growers of sweet potatoes become disheartened and abandon the crop for both present and future.

[1] *Cylas formicarius* Fab.

[2] Few reports are made unless the damage is most decided. As in the case of many other crops, a monetary loss due to insects of less than 20 per cent is too frequently unnoticed by the average grower, or, if observed, is likely to be attributed to unfavorable weather or to other conditions.

Mr. Wilmon Newell, commissioner of the Plant Board of Florida, who is actively cooperating in the sweet-potato weevil investigations, in writing of this insect in the autumn of 1917, stated that from 30 to 50 per cent of the crop at digging time was lost in many portions of that State; that the roots were discarded as "weevily"; and that where the roots were stored their destruction by the weevil was completed by spring. He believed that an insect capable of making serious inroads on the sweet potato crop, if it became generally distributed throughout Florida, might cause a direct loss to the farmers of $1,000,000 annually. Many similar instances of injury have been reported in that State, as well as in Louisiana and Texas.

EXTENT OF LOSSES.

It is estimated that Texas, with a sweet-potato crop in 1917 valued in round numbers at $9,000,000, has suffered a loss of 20 per cent, or $1,800,000 a year, from the attack of this weevil; Louisiana, with a crop valued at $5,000,000, has lost about 12 per cent, or $600,000; and Florida, with a $4,000,000 crop, has lost about $400,000. Thus a conservative estimate of the total yearly loss due to the ravages of this pest in these three important sweet-potato growing States alone is $2,800,000.

The extent of injury in the States of Georgia, Alabama, and Mississippi, and in the insular possessions, Porto Rico, Hawaii, and Guam, is not known. It is impossible to estimate the money loss traceable directly or indirectly to this weevil because of the failure of planters to grow sweet potatoes through fear of a recurrence of losses sustained in earlier years. The amount, however, undoubtedly is very large and must be given serious consideration.

The loss to the Gulf country has been estimated by Newell at $3,500,000—a sum which can not be far from correct.

If radical measures for the suppression of this pest are not adopted soon, the example set by many planters who have abandoned all attempts to produce this important food crop commercially will undoubtedly be followed by others who have suffered losses, and the supply of sweet potatoes will be reduced greatly.[1]

[1] This article must be considered as of a preliminary character and is published at the present time that the sweet-potato growers in the infested regions may be informed concerning the known facts with regard to the insect in its different stages, the losses which it annually entails, its present distribution, its food plants, its life economy as far as learned, and, above all, the methods for its control which experience has shown to be of the greatest importance. The investigations now being undertaken in the South by the Bureau of Entomology and the various State and other official entomologists will result in additional information concerning its distribution, its complete life history, the value of heat and fumigation in protecting seed potatoes, the effect of arsenicals on the insect, and the results of other methods of control which have not been fully demonstrated.

In the preparation of this article the author has had the active cooperation of Messrs. John E. Graf and C. H. Popenoe, who have conducted surveys of the infested regions, read the manuscripts, given suggestions, and furnished photographs for reproduction. Mr. M. M. High has supplied data relating to the life economy; Mr. B. L. Boyden, on the effect of carbon disulphid on the tubers. Information has been obtained also from the bulletins of Mr. Wilmon Newell and Dr. W. E. Hinds on this subject.

SOURCES OF INFESTATION.

Wherever this insect is well established the principal infestation takes place through the overwintered weevils. Weevils may winter over in three ways: (1) In stored sweet potatoes; (2) in roots left in the ground as volunteers; or (3) in those left through poor harvesting. Wherever temperatures below 10° F. are frequent during the winter these methods of hibernation are responsible for the continued presence of this pest, since that temperature is fatal to adults which are not protected. Weevils in all stages may be found in buried roots along the Gulf coast during the winter.

With regard to weevil injury no practice can be worse in infested districts than that of preserving a permanent bed of seed sweet potatoes, from which vines can be cut for planting *at the convenience of the grower*. This practice is certain to result in the transmission of an abundant supply of weevils to the main crop, and is equally certain to cause serious injury to the crop by the time it is ready for harvest.

An outbreak of the sweet-potato weevil in a new locality, remote from any other where it is known to be established, in practically every case may be traced to the transportation of propagation material from weevil-infested localities. Indeed, it is a matter of surprise that the insect has not been more widely distributed than available records show.

All sweet-potato growers, all dealers, and all transportation companies, whether railroads or steamship lines, should be posted thoroughly regarding the danger in the case. All portions of sweet-potato plants, cuttings, vines, draws, and slips, and especially seed tubers or roots, and all wild morning-glories, should be carefully examined for the presence of this weevil before being shipped from weevil-infested regions or admitted into uninfested or weevil-free regions.

The growing of sweet potatoes by small planters, for home use only, provides a potent source of infestation in the infested Gulf States. Where holdings are small, effort to store them to prevent loss is necessarily extremely limited. Many such growers practice no methods of control and count on saving not more than from 60 to 70 per cent of the entire crop, the remainder, 30 to 40 per cent, being left to the mercy of the pernicious weevil and to rot. Such small, scattered areas, in proximity to extensive farms where sweet potatoes are grown commercially, constitute a menace which it would be almost criminal to overlook.

To meet such conditions State quarantine regulations should be placed in effect that will oblige the small grower either to take proper care of his own crop or permit the same to be destroyed in

case of the impossibility of saving it by cleaning up, fumigation, or otherwise. In just such cases a duly authorized horticultural inspector or county agent could render his greatest service both to the community and to the country at large.

The commercial grower will serve his own interests in the highest degree by pressing legislation of this character in every way possible.

DESCRIPTIVE.

The sweet-potato weevil has four distinct stages: (1) The adult, or weevil; (2) the egg; (3) the larva, or grub; and (4) the pupa, or resting stage. The grower should be able to identify these with the aid of figures 1, 2, and 3 and the following brief descriptions:

THE ADULT.

The adult (fig. 1) of the sweet-potato weevil is a snout-beetle of ant-like appearance, about one-fourth of an inch long, with metallic dark-blue elytra or wing-covers. It is slender, cylindrical, with distended or "swollen" body and long legs. The prominent head and beak are dark blue and the thorax or "waist" is brick red, as are also the sides of the legs; the long antennæ or "feelers" are yellowish red. The antennæ have long, thick clubs at the ends, and the male, which bears the longer club, can be distinguished from the female.

THE EGG.

The egg is pale yellowish, broadly oval, somewhat narrowed at the attached end; the surface is not polished, but shows slight granulation and a faint appearance of division into facets. The length is about one-fortieth of an inch (0.65 mm.).

THE LARVA.

The larva (fig. 2), when full grown, is cylindrical, robust, with the lateral edges of each segment prominent and rounded. The color is nearly pure white, the head pale brown, and the mouth-parts dark brown. A few sparse, delicate hairs can be seen under the microscope. On the thoracic segments there are three pairs of broad leg-pads. The length is about three-eighths of an inch (9 mm.).

THE PUPA.

The pupa (fig. 3) is at first of the same color as the larva, but grows darker just before transformation to adult. The wing-pads are short and narrow and are folded over on the lower side of the body. The head and back fold down upon the breast. The last segment is furnished with two backward and outward curved tubercles. On the head are several minute tubercles, each of which bears a slender hair. It is about one-sixth inch (4 mm.) long, or the same as the beetle without the beak.

The pupa is inactive, not partaking of food. The lower half of the body is mobile, enabling the pupa to turn about in its burrow or pupal case.

DISTRIBUTION.

The distribution of the sweet-potato weevil is a matter of the greatest importance, since it is necessary, in an effective "clean-up" campaign, to know the exact localities wherein the insect is established as well as to know those in which it does *not* occur.

This is especially well illustrated by reference to the Baker-Charlton region in southern Georgia and northern Florida. (See map, fig. 4.) In this area, in a comparatively restricted locality, the weevil, within the last few years, has become a menace to the sweet-potato crop, having become introduced obviously through infested propaga-

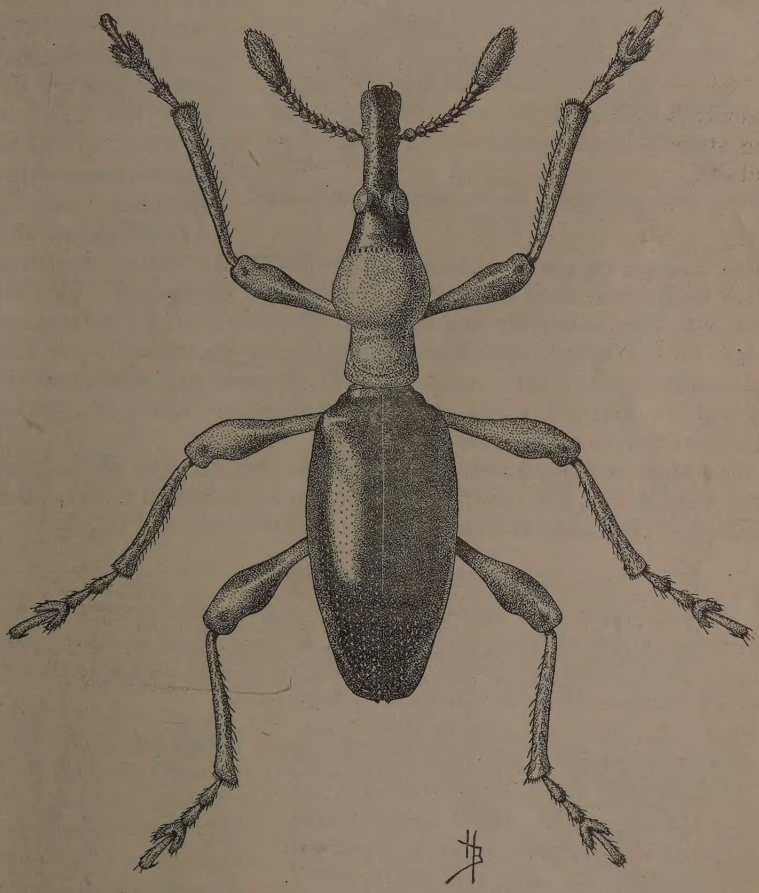

FIG. 1.—The sweet-potato weevil (*Cylas formicarius*): Adult beetle. Greatly enlarged. (Pierce.)

tion material. Since a most thorough survey has established that this is an isolated infestation, being confined by a well-marked boundary, and since it is possible through an effective quarantine organization to control almost completely the movement of infested roots and draws, this infested area has been selected for demonstration purposes, and a complete record of all infested farms or gardens therein

is available. The widespread publicity incident to the farm-to-farm survey which has been undertaken has borne fruit to the extent that a probable reduction of 25 per cent in the infested area already has been accomplished, principally through educational methods, and it is believed that within two years it will be possible to remove the quarantine now in force against this area because of the completion of projected eradication measures.

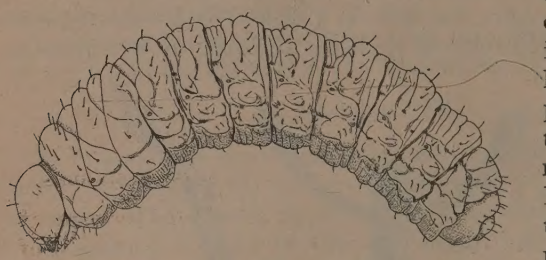

FIG. 2.—The sweet-potato weevil: Larva. Much enlarged. (Pierce.)

A similar survey of the southern counties of Mississippi, which are the only ones positively known to be infested, affords a substantial basis for the institution of control and clean-up measures there. This accomplished, the early establishment of repressive measures will operate to destroy the pest, stop its breeding, and, above all, prevent its spreading to weevil-free regions.

For these reasons, a somewhat complete consideration of the present distribution, the trend of distribution as indicated by available data, and the limits and extent of this distribution will follow.

TREND OF DISTRIBUTION.

Records show that the sweet-potato weevil was present in the vicinity of New Orleans, La., in 1875, and near Manatee, on the west coast of Florida, in 1878. Undoubtedly it was introduced with sweet potatoes at an earlier time in both localities. Since the time of these introductions, the insect has been distributed along the Gulf and Atlantic seaboard, and has spread inland from these points. Commerce along the Atlantic seaboard and through the large and small waterways has facilitated its movements, and the area of distribution has been increased through the shipment of weevil-infested sweet potatoes, intended for food as well as for seed, to still other points inland, in many cases involving considerable distances.

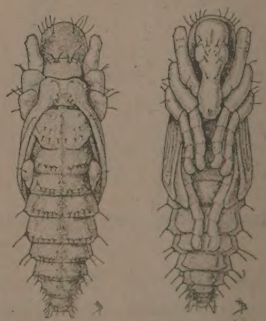

FIG. 3.—The sweet-potato weevil: Pupa, dorsal and ventral views. Enlarged. (Pierce.)

The chief points of introduction of the weevil in this country seem to have been independent of each other and its range has been ex-

tended from no single place, but from several widely separated centers, which, in addition to New Orleans, La., and Manatee, Fla., probably include Key West, Fla., in 1880, and Miami, Fla., and localities in Galveston and Harris Counties in Texas in 1890—all of which are ports of entry for the West Indies trade.

In Texas the trend of distribution is northward, in Louisiana westward and northward, with very slight movement to the East. In Florida the insect has held closely to the Atlantic and Gulf regions, having made little progress toward the interior.

A prediction that the species would move eastward into Alabama from Pascagoula, Miss., or some more eastern point has been verified

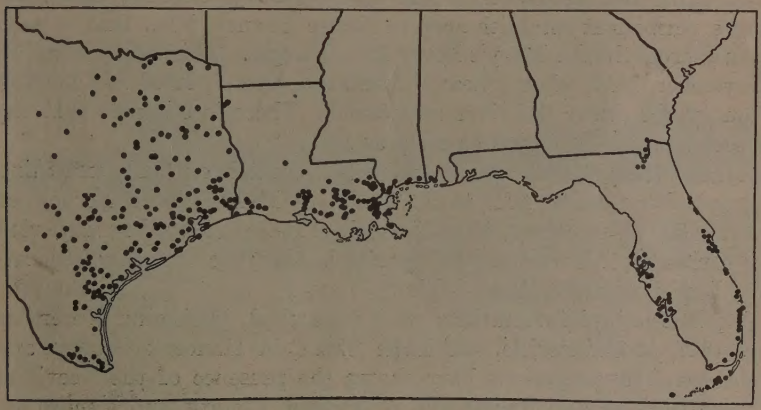

FIG. 4.—Present known distribution of the sweet-potato weevil in the southern United States.

by Mr. K. L. Cockerham, special field agent, who discovered the species and its injurious work in Mobile County, Ala., February 21, 1918.

In Texas the weevil ranges from Brownsville and Pharr on the Mexican boundary, in Cameron and Hidalgo counties, respectively, westward to Callahan County and northward to Fannin, Red River, and Bowie counties, which border the Red River. From these three counties the weevil can be carried across the river to Bryan, Choctaw, and McCurtain counties in Oklahoma, while Mill and Lake counties in Arkansas are threatened.[1]

To summarize, the sweet-potato weevil has long been an inhabitant of Florida, Louisiana, and Texas, and since the question of its suppression was raised in the fall of 1917, it has been learned that it has entered Georgia through northern Florida, or vice versa; Mis-

[1] Large areas of these counties are in forest land and the acreage in sweet potatoes is small. If these should become infested the pest could be stamped out readily.

sissippi (in four counties) has become infested from Louisiana; and Alabama has been entered from Mississippi. Should future survey work show that infestation occurs in Tennessee,[1] a State reported as harboring the weevil, Oklahoma, Arkansas, North and South Carolina, and even Missouri and Kentucky may be invaded, unless drastic action is taken to suppress the pest along the border lines of all the States in which it has become located.

PRESENT DISTRIBUTION.

Up to November, 1917, there was no positive knowledge of the occurrence of the sweet-potato weevil in States other than Florida, Louisiana, and Texas, but it had been surmised, considering the insect's permanent establishment in Baker County, Fla., that it soon would cross the St. Mary's River into Georgia. This was verified in November, 1917, when a heavy infestation was reported in Charlton County, Ga., near the river mentioned. There is evidence that the insect was in that region as early as 1915.

Along the Gulf of Mexico there is a stretch of land, extending from Baker County, Fla., to St. Tammany Parish, La., a distance of nearly 600 miles, which up to November, 1917, had not been reported as harboring this weevil. This parish borders the State line separating Louisiana from Mississippi.

In Mississippi infestations were unearthed, beginning December 18, 1917, at Gainesville, and Lake Shore, in Hancock County, and additional investigations have shown the presence of the weevil at Ocean Springs and Pascagoula in Jackson County, and a more extensive distribution in Hancock County, while it has also invaded Pearl River County. (See map, fig. 4.) Many new localities have been reported since in this same region, the infestations varying from 5 to 75 per cent. The weevil is reported to have been present in many cases since 1915 and in one as early as 1914.

The sweet-potato weevil can survive the winter in every State where sweet potatoes are extensively grown and stored, and should its range extend farther along the lines indicated the possibilities of damage to this important crop would be enormous.

FOREIGN DISTRIBUTION.

The origin of the sweet-potato weevil is unknown, but it is assumed to be native to Cochin China, Mauritius, India, and other countries, although its exact distribution abroad never has been care-

[1] A report, happily unverified, has been received of the occurrence of this insect in four counties in Tennessee. If a suspected fifth county should be found later to be infested it means that the weevil is on the border line between Tennessee and North Carolina and that the latter State is menaced. Another county, Robertson in Tennessee, borders Kentucky.

fully studied. It has been recorded, however, from different portions of Asia and Africa and from outlying islands of both continents, the list including India, Ceylon, Cochin China, Hongkong, Mauritius, Uganda Protectorate, Gold Coast of Africa, Friendly Islands, Formosa, Madagascar, Australia, Hawaii, Guam, and practically all of the West Indies—Cuba, Porto Rico, Haiti, Grand Cayman, and Jamaica—and British Guiana in South America. It has also been known as a pest in Australia, at least since 1889.

Evidence points to Cuba as the source of its introduction into the United States. This was undoubtedly before 1875, when the species first was identified in connection with injuries to the sweet potato. Introductions have taken place frequently since that time.

FIG. 5.—View of Florida beach, showing characteristic spreading growth of the beach morning-glory, a wild food plant of the sweet-potato weevil.

Some other localities attributed to this species in reality refer to what we now consider a distinct species,[1] with similar habits. Still another related weevil,[2] occurring in Liberia, attacks the sweet potato.

FOOD AND OTHER HABITS; NATURE OF INJURY.

The sweet-potato weevil is restricted for food to the sweet potato, including the types known in some sections as "yams,"[3] and closely related plants,[4] prominent among which is the goat's-foot morning-glory,[5] considered a natural food plant. This plant is a nearly cosmopolitan weed which grows in sandy places along tropical seashores.

[1] *Cylas turcipennis* Boh., from Java, India, and Sarawak.

[2] *Cylas femoralis* Faust. For descriptions and other matter in relation to these species see W. D. Pierce, Journ. Agr. Research, Vol. XII, 1918, pp. 604–607.

[3] It does not attack the true yam (Dioscorea).

[4] Botanical family Convolvulaceae.

[5] *Ipomoea pes-caprae*, also called the beach vine and seaside or beach morning-glory.

Its characteristic spreading nature along the beaches of Florida is shown in figure 5. The sweet-potato weevil infests more rarely a species of wild moonvine or moonflower.[1] It breeds also on other plants of the morning-glory family,[2] and is at times extremely abundant on volunteer or wild sweet potato.

In figure 6 is shown a corner of a vacant lot in southern Florida where a mat of volunteer sweet-potato vines badly infested by the sweet-potato weevil has accumulated.

The beetles injure the sweet potato by feeding on the leaves, vines, stalks, and roots or "tubers."

The female weevil lays her eggs in the vines, and in the stalks or crowns, near the ground, as also in the roots in the field, and continues to work and breed in the roots in storage. The larvæ on

FIG. 6.—Corner of a vacant lot in southern Florida, showing mat of wild or volunteer sweet-potato vines badly infested by the sweet-potato weevil.

hatching tunnel through the vines to the roots, the vines die, and frequently the roots become badly riddled and filled with excreta, imparting such a bitter taste that even swine will not eat them. A cross section of such a root is shown in figure 10. Within a short time, if the insects are numerous, the roots are completely destroyed, and breeding continues almost indefinitely after decay has become advanced until finally the roots become either too moist or too dry and hard to permit further weevil development.

One form of injury is accomplished by the first-appearing weevils. After feeding on the leaves, stems, and vines enough eggs are deposited at the base of the vine to girdle it more or less completely, thus impairing its vitality before it is old enough to bear roots.

[1] *Calonyction aculeata.*

[2] This includes *Ipomoea littoralis, I. trifida, I. trichocarpa, I. pandurata,* and *Jaquemontia tamnifolia.*

Many weevils undergo transformation within the base of the vine before the roots have attained much growth.

In regions where this weevil has long been established as a pest the careful housewife has learned to examine the sweet potatoes with a knife before cooking, cutting out the affected portions, otherwise they could not be eaten because of their bitter taste.

THE WEEVIL IS WINGED, BUT APPARENTLY TRAVELS SLOWLY.

At first sight the sweet-potato weevil appears to be wingless, but it has a pair of rather delicate-looking wings which it uses infrequently, only a few instances of flight having been recorded, in none of which the weevils flew far. If the theory that the weevil does not spread materially by flight is correct,[1] the insect will be easy to control, and the advantage which is thus offered toward its eradication may be readily appreciated by those who suffer annually from its ravages. Present knowledge indicates that its spread can scarcely be effected by flight, but is made possible through commercial movements of its food plant as previously described.

SEASONAL HISTORY.

The sweet-potato weevil passes through no very definite hibernation and is more or less active throughout the year in the Gulf States, unless restricted by low temperatures. Eggs, larvæ in different stages, pupæ, and adults may be found throughout the winter over the greater part of its range. Conradi states that little egg laying takes place during the three winter months, but the beetles are active on warm winter days, crawling rapidly about and feeding on stored roots with avidity.

In the field the beetles assume greater activity as soon as the young slips begin to appear in the seed bed. They feed first on the leaves and stalks of young plants, eating irregular holes in the leaves and making excavations in the stalks, which are particularly conspicuous near the surface of the ground. After the stalks reach sufficient size and begin to become woody, the eggs are deposited on the roots just below the earth line. The usual course taken by the female is to follow the vine to the roots and to deposit the eggs there. In soils subject to the formation of deep cracks in time of drought the eggs may be laid on the roots after they have reached the size of one's finger.

The young larvæ eat into the flesh of the potato, leaving an irregular mine or burrow lined with excrement. They burrow and

[1] Additional investigations to ascertain the extent of the flight of this weevil are being conducted, and will be continued in different localities under varying conditions. Possibly the insect may be distributed to some extent by winds, as in the case of the Colorado potato beetle.

feed throughout the root until their full growth is reached, then construct a more or less oval cavity at the end of the burrow, usually within one-fourth to one-half inch of the surface of the root, and there transform to pupæ.

FIG. 7.—Sweet potato, nearly fresh, showing exit holes and feeding punctures of sweet-potato weevil toward stem. Note outer end scarcely attacked. Sample from Louisiana.

The adults emerge through irregular openings in the skin, many frequently issuing through the same hole. In figure 7 is shown a freshly harvested sweet potato in which exit holes and feeding punctures both appear. The characteristic severity of attack toward the stem end is well exhibited. As attack progresses and the roots become more seriously infested, especially in storage, they develop a tendency, provided they do not rot, to become quite dry, frequently imprisoning the weevils in the burrows and causing their death. Typical examples of infestation of this character are shown in figures 8 and 9, for comparison with the preceding.

Weevils in sweet potatoes left in the ground frequently perish in their burrows through fungus attack, especially should the soil be unduly moist, but they continue to breed in roots after these are too moist or dry for any useful purpose.

NOTES ON THE LIFE CYCLE.

Observations conducted by Mr. M. M. High in southern Texas show the possibility of a single beetle depositing upwards of 300 eggs. As many as 10 eggs have been deposited in a single night, and as many as 4 in three hours' time, the process of laying a single egg being quite protracted. The highest number deposited in one day of 24 hours was 18. Eggs are not laid in the feeding punctures, but in cavities especially prepared for them. These usually are bored at an angle of about 60 degrees, while the feeding punctures usually are perpendicular.

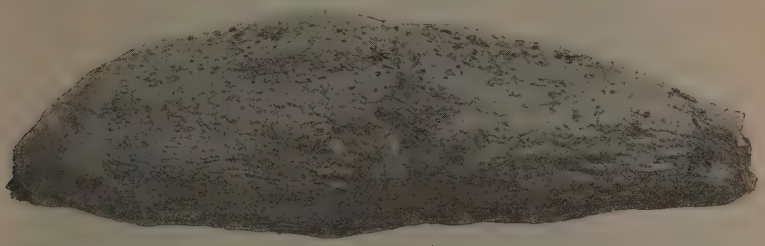

FIG. 8.—Sweet potato beginning to dry, showing punctures made by sweet-potato weevil, chiefly for food. Interior highly infested and root much shrunken.

Figure 8 shows a heavily infested sweet potato bearing on the outer and lower surface scars or punctures made chiefly by the adult weevil for feeding purposes. The interior contained many weevils, larvæ, and pupæ. On the upper surface of this root considerable shrinkage and few punctures or holes appeared. This shows how attack and consequent deterioration continue after infested roots have been harvested.

Transformation from egg to adult has been observed to last in warm weather about 30 days and in cooler weather it undoubtedly takes 42 days or longer. The entire life cycle from egg to egg in warm weather would consume about 5 weeks and in cooler weather

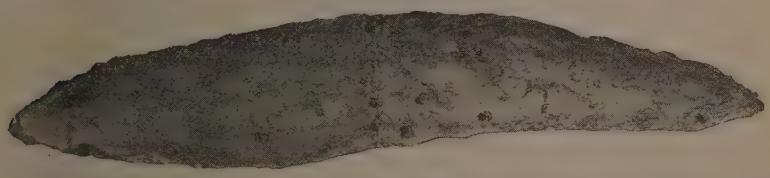

FIG. 9.—Sweet potato badly infested by sweet-potato weevil, decidedly dry, but showing break at middle where living larvæ, pupæ, and adults were found. Somewhat reduced.

6 or 7 weeks. The pupal period has been observed to last 8 days and the egg period from 4 to 8 days according to temperature, which would leave from 2 to 4 weeks for the larva or active stage.

NATURAL ENEMIES.

The sweet-potato weevil is, so far as known, remarkably free from natural enemies. It is unable to escape from roots when they be-

come too dry and hard; when they become too moist and rots set in, the same effect is produced.

A mite affects the adult, but it probably has no material effect on the life of the weevil.

The red and yellow colors of this insect on the metallic blue background of the body are undoubtedly of a warning nature.[1]

FIG. 10.—Cross section of sweet potato showing injury by sweet-potato weevil. Larva in burrow at top; pupa below; openings to tunnels elsewhere. Enlarged 3 diameters.

It seems probable that the sweet-potato weevil may be held in check by some natural enemies in its native home in the Orient, since comparatively little has been learned of the ravages of this pest in that region.

CONTROL.

In considering remedies for the sweet-potato weevil it should be remembered that the insect breeds exclusively on sweet potato and closely related plants such as morning-glory and bindweed, and that

[1] They resemble those of some predacious insects such as the great lebia (*Lebia grandis* Hentz), a most important enemy of the Colorado potato beetle, which is protected by its warning color from rapacious birds.

it does *not* breed on any other crop. The beetle, although provided with wings, is seldom seen in flight, and, being necessarily a slow traveler, its spread from one region to a distant one is effected by commerce. If it did not breed naturally on the weeds which have been mentioned, and especially on the seaside morning-glory, it would be comparatively easy to prevent absolutely its further distribution by instituting quarantine and other preventive measures. In any event quarantine measures will prove of the greatest value.

PREVENTING TRANSPORTATION FROM INFESTED TO UNINFESTED REGIONS.

Since the sweet-potato weevil, because of its limited powers of flight, can be distributed extensively only through transportation of infested tubers or propagation material, scrupulous care should be exercised by planters to see that propagation material is brought only from sections known to be free from the weevil.

Since investigations indicate that the weevil is capable of surviving the winter in nearly every sweet-potato growing section of the United States, the importance of prohibiting by legislation the shipping of infested sweet potatoes into districts where this insect is capable of becoming established can not be too greatly emphasized.

QUARANTINE REGULATIONS.

All States in which the sweet-potato weevil is known positively to occur have adequate crop-pest laws which permit the establishment of interstate and intercounty quarantines against insect pests. Quarantine measures have been adopted also by the States of Florida, Georgia, and Alabama, especially directed against the sweet-potato weevil. Except in Texas, the quarantine legislation prohibits the transportation of sweet-potato roots, plants, draws, and slips and of related plants from a weevil-infested locality to regions where the insect is unknown. Close cooperation with State and Federal authorities in the enforcement of these measures will accrue to the advantage of sweet-potato growers by reducing the annual losses from the attack of this weevil.[1]

It is especially urged that commercial plant growers provide for inspection whenever engaged in the shipment of seed potatoes and other propagation stock for planting, and that growers who purchase all or any portion of their planting stock insist that the shipment be accompanied by a certificate of inspection. This will prove a protection not only to the grower but to his entire neighborhood as well.

[1] For information with regard to these quarantine laws growers are referred to the following publications:
For Florida, Quar. Bul., State Plant Bd. Florida, Vol. II, Oct., 1917.
For Georgia, Circ. 27, Ga. State Board Entom., Feb., 1918.
For Alabama, Circ. 37, Ala. Agr. Exp. Sta., Feb., 1918.
For Louisiana, La. State Board Agr. & Imm., Rule 21.

Concerted, decisive, and prompt cooperative action by growers, with inspectors and other State or Government officials employed in the enforcement of quarantine measures, may keep any community permanently free from this weevil, while every obstruction placed in the way of such enforcement favors the pest. Every grower should make sure that the weevil does not gain entrance to his neighborhood through any act of his, and should take pains to report to the proper authorities any suspicious injury to sweet-potato plants or tubers which may come to his attention. He should do everything that in him lies to keep the community, the county, the State, and the country free from this pernicious enemy of food production.

CLEAN CULTURE.

In addition to any remedies that may be employed, it is always advisable, in order to prevent the development and increase of this pest, to clean up infested fields promptly and destroy all vines, stems, tubers, and other remnants. Afterwards the ground should be deeply plowed or harrowed and kept free from volunteer potato and morning-glory vines.

Upon the thoroughness with which this work is done will depend immunity from further losses. In other words, upon promptness and scrupulous cleanliness depends a good crop.

USELESS SWEET POTATOES, IF NOT FED, SHOULD BE BURNED.

Every sweet potato should be carefully gathered from the field and the crop divided as nearly as possible into three lots: (1) Weevil-free roots; (2) roots slightly infested, for disinfection; (3) roots badly infested. The last, or culls, together with every remnant of an unsalable nature, should be gathered and fed to hogs, cattle, or poultry, after cooking them, to insure that no weevils may escape to reproduce their kind and restock the fields. If, however, they should prove to be unfit for stock, they should be burned with the vines immediately after harvest. This process can be facilitated by the addition of any ignitable material, such as straw, dry weeds, paper, or oil.

By careful attention to "hogging down" after harvesting, a grower who maintains a herd of pigs like those shown in figure 11 has disposed of his culls and "strings" at a good price, and has for a number of years kept weevil injury below 5 per cent in a region where it averages more than 50 per cent.

CROP ROTATION.

Rotation of crops is a necessary measure in the eradication of this pest: indeed, injury may be prevented to a large extent by the selection of the field for planting. This should be as remote as possible from old weevil-infested fields, and any other crop such as corn, cot-

ton, tobacco, Irish potatoes, or a truck crop other than sweet potatoes may be grown between, as also on the infested area. This will lessen if not prevent infestation of the new field and is good farm practice, costing practically nothing. Where a natural barrier, such as a wood-lot or windbreak, stands between the old infested field and the new field it is of some value.

PLANTING THE NEW CROP REMOTE FROM THE SEED BED.

The practice of planting the main field of sweet potatoes as far as possible from the seed bed has been followed with excellent results by a number of large growers in regions where the weevil threatened the existence of the crop. It has been found that the heaviest losses were sustained where the seed potatoes were bedded in close proximity to the field in which the main crop was produced, and that when the seed beds were widely separated from the main field the

FIG. 11.—Part of a drove of pigs raised by a progressive ranchman of Brazoria County, Tex., as a useful adjunct to commercial sweet-potato growing.

damage was correspondingly reduced. One extensive grower, whose fields were located in a section subject to annual weevil injury exceeding 75 per cent of the crop, reported an average loss of less than 5 per cent since adopting this practice, in connection with that of "hogging down."

Even better results may be reached through a practice of planting the slips or draws in a separate plat at a distance from the bed in which they are produced, and cutting the vines grown from these for the main crop at least 10 inches from the root. The main crop should, of course, be isolated from both the bed and the plat, which should be destroyed after their use for propagation has been served. The danger of carrying weevils to the main crop is thereby greatly reduced, since it is well known that any eggs or larvæ which might remain over will be left in the basal portion or crown of the vines.

DISINFECTING THE ROOTS.

Where sweet potatoes are not too badly damaged by the weevil they may be disinfected and the insects destroyed by means of carbon disulphid evaporated in tight receptacles. The use of this fumigant for sweet potatoes in storage bins has been recommended by several entomologists and there is no doubt whatever of its effectiveness with a proper dosage and under suitable conditions. The results obtained from its use both by growers and in experiment by agents of the Bureau of Entomology, however, indicate that under unfavorable conditions fumigated roots may fail to germinate or sprout, or may become subject to rapid and complete decay. The factors concerning this failure of effectiveness under such conditions appear to be primarily the high moisture content of the tubers, but include also the time of exposure, the condition as to curing, and temperature, with perhaps others as yet undetermined. These conditions are the subject of experiment at present, and complete data are not obtainable. Sufficient information, however, has been obtained to emphasize the necessity of a positive determination of these factors before the widespread use of carbon disulphid as a fumigant may be recommended unconditionally. Growers, therefore, are advised to proceed with extreme caution in the use of this chemical for the fumigation of sweet potatoes unless they are to be consumed immediately.

SPRAYING WITH ARSENICALS.

With the knowledge that the adult weevils feed on the leaves and stems of the slips, zinc arsenite and lead arsenate were tested as a remedy by Mr. High in southern Texas. In the first experiment made, where an actual count was possible, 80 per cent of the weevils were killed with zinc arsenite at the rate of 1 pound of powder to 40 gallons of water, with 15 pounds of cactus solution used as a "sticker" and "spreader."[1] Repeated experiments with this compound, and with lead arsenate in the same proportion, were made, showing that spraying would greatly lessen the damage if applied at the proper time. Another test was made with zinc arsenite, 1 pound to 30 gallons of water and 12 pounds of cactus solution, with the result that the infestation was only one-fourth as great on the sprayed as on the unsprayed plat. In another experiment at the same rate, 7 pounds of infested roots were counted from the sprayed plat, while on an unsprayed area of the same size 29 pounds were infested. In the last experiment reported, in the same proportion, 3 pounds of infested roots to the bushel were obtained on the sprayed area, while on the unsprayed check 16 pounds were infested to each bushel.

[1] See "Cactus Solution as an Adhesive in Arsenical Sprays for Insects," Bul. 160, U. S. Dept. Agric. A formula substituting 3 pounds of soap to 50 gallons of water would be productive of practically the same results.

The spray should be applied for the first-appearing beetles; a second should be used and, in the case of heavy infestation, a third, at intervals of about 10 days.

Before setting out the plants they should be dipped in lead arsenate, 1 pound to about 10 gallons of water.

The precise value of the use of arsenicals as a spray against this weevil remains to be ascertained. Experiments are under way to determine this.

IMMUNE VARIETIES OF SWEET POTATOES UNKNOWN.

Observations indicate that the weevil attacks all varieties of sweet potatoes with equal facility, although the sweeter yellow varieties, called "yams" in the South, appear to be preferred. Some growers believe that earlier varieties suffer more severely than later ones, but this theory is not borne out by the experience of others, who assert that there is no marked difference. Observations conducted by Mr. High show that late-planted sweet potatoes, as a rule, do not harbor as great a number of weevils as occur in the case of early plantings, but that notwithstanding even late plantings may be completely destroyed.

Where sweet potatoes are grown in light, sandy soils which are not subject to the formation of deep cracks during dry weather, it has been learned that the deeper-growing varieties are less liable to infestation, because they are not so readily reached by the beetles.

In the many lots of sweet potatoes examined by the writer there is nothing to indicate that the weevil has different tastes from other insects, which as a general rule attack the choicest varieties in preference to those which are less palatable or more resistant to rots in store. Observations recorded in this country are practically the same as those noted by Tryon in Australia.

GENERAL INSTRUCTIONS.

Every case of infestation, whether a field, garden, or smaller area, should be thoroughly investigated from every point of view and all possible precautions taken to keep the sweet-potato weevil under control. The following general measures should be observed:

HARVEST PROMPTLY.

Prompt harvesting should be practiced. The roots, if found to be weevil-infested, should be fumigated promptly and thoroughly as soon as dug, before being placed in temporary storage prior to shipment. This will prevent further injury from weevil attack, which will practically cease at once.

AVOID SCATTERING THE WEEVILS.

Infested sweet potatoes should be sacked or barreled before being carried to the storage house or "pits" in order that unnecessary scattering of the beetles along the way may be prevented.

KEEP DOWN THE WILD PLANTS.

All morning-glories, whether wild or cultivated, especially the seaside morning-glory, and all volunteer sweet-potato plants should be kept down on the farm, as they furnish permanent breeding places for the weevil. Sweet potatoes should not be planted where these plants have been allowed to accumulate. Figure 6 shows the corner of a vacant lot in southern Florida in which wild or volunteer sweet potatoes accumulated and became heavily infested with weevils.

CARE IN STORAGE.

Storage houses and pits should be constructed at points remote from the sweet-potato field. All storage structures should be kept as dry as possible at all times, not alone because injurious attack by the sweet-potato weevil will be discouraged, but that storage losses from other causes, such as rots superinduced by weevil attack, may be decreased. They should be so constructed as to be available for fumigation, and to permit of inspection for weevil attack from time to time. Sweet potatoes stored in the manner shown in figure 12 can not

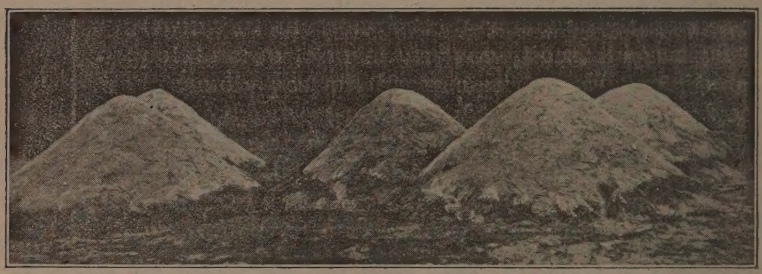

FIG. 12.—Sweet potatoes stored in "banks" on a Florida farm.

be readily inspected or fumigated. These would require more thorough casing before treatment with carbon disulphid, since the sandy soil and the ventilation secured by means of pine needles would result in excessive gas leakage.

The use of a storage house of the nature illustrated in figure 13 is certain to result in the loss of the crop if used in infested districts. In this house the weevils were active during the month of January. It can not be fumigated, it permits the freezing of the crop during a "norther," and during warm weather becomes so hot that weevil activity is stimulated. The sweet potatoes stored here were more than 90 per cent infested by the sweet-potato weevil.[1]

Before placing weevily sweet potatoes in storage it is advisable to clean them thoroughly and then disinfect the storehouse by fumigation with sulphur, a process which is strongly advised by Dr. W. E. Hinds, entomologist of the Alabama State Experiment Station.

The fumes of sulphur are harmful to plant life, hence sweet potatoes treated with this fumigant would be valueless for planting, the gas destroying the germinating qualities of the roots.

[1] The sweet-potato grower is referred to Farmers' Bulletin 970, "Sweet-potato Storage," by H. C. Thompson, issued in May, 1918, which may be obtained free on application to the Division of Publications. This bulletin furnishes information on the importance of the sweet-potato crop and full instructions as to the construction of storage houses for sweet potatoes.

COOPERATION.

Strict cooperation in the employment of the methods here advised in a single season will greatly reduce losses from the sweet-potato weevil. The weevil is, indeed, a species that might have been stamped out long ago if each grower had done his share toward destroying the insect or preventing its breeding on his own farm and had encouraged his neighbor to do likewise.

In several localities this insect has been eradicated by the employment of such simple methods as those advised or by abandoning completely the cultivation of sweet potatoes. The former step is necessary, the latter is an extreme measure, not at all necessary, because rotation of crops, as advised under the heading "Crop rotation," page 18, will accomplish the same object. Cooperation is not only the most

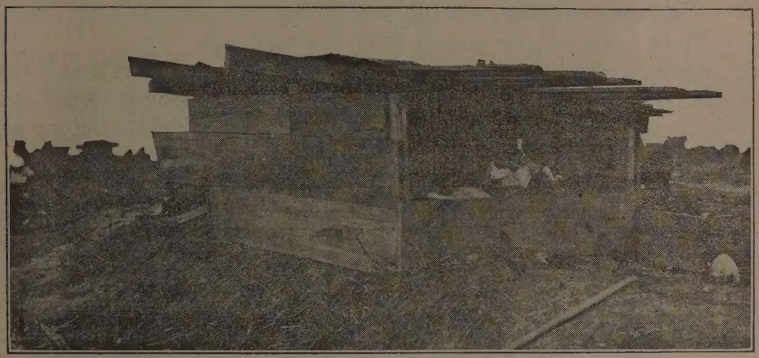

FIG. 13.—A poor type of storage house for sweet potatoes.

necessary measure, but without it the control and eradication of the sweet-potato weevil will not be possible.

SUMMARY OF CONTROL MEASURES.

(1) Do everything possible to prevent the transportation of weevil-infested plants to uninfested districts.

Do not use for planting seed sweet potatoes, slips, or draws from weevil-infested localities, but obtain them from localities in which the weevil positively does not occur.

(2) Never use the same land for growing sweet potatoes year after year where weevils are present.

Rotate with cotton, corn, tobacco, Irish potatoes, peanuts, or any other profitable crop.

(3) Harvest promptly and thoroughly, gathering all tubers or roots. In infested regions sort tubers into three lots: (1) Those which are practically weevil-free, for storage; (2) those which are

moderately infested, for fumigation and early consumption; (3) those which are too badly weeviled, or otherwise injured, for food, to be cooked for stock or burned.

(4) Disinfect all weevily roots, wherever advisable and practicable (e. g., when soon to be eaten), with carbon disulphid or other fumigant.

(5) Destroy the weevils in badly infested and inferior roots by cooking and then feed to hogs, poultry, or cattle. Even if the infested roots are so badly damaged as to be bitter they may be fed if mixed with other feed for hogs.

(6) After cleaning up the culls, vines, remnants, and rubbish remaining in the fields after harvesting, burn them promptly and thereafter keep the fields clean at all times.

(7) Keep down volunteer sweet potatoes and all plants of the morning-glory family, whether cultivated or wild.

(8) Plant the new crop remote from the seed bed.

(9) Spray plants with arsenicals for first-appearing weevils on leaves and stems. Dip the slips and other propagation material into arsenate of lead before planting. Kill the beetles before egg laying begins and whenever they appear in numbers.

(10) Observe care in storage, keeping tubers dry at all times to prevent secondary injury from rots.

(11) All States in which the sweet-potato weevil occurs have adequate crop-pest laws which permit the establishment of both interstate and intercounty quarantines against this pest. Close cooperation with State and Federal authorities will be advantageous to growers in reducing losses from weevil attack. It is especially urged that commercial plant growers provide certificates of inspection for weevils when shipping plants or seed potatoes for planting, and that all growers who purchase planting stock insist that a certificate of inspection be furnished. Aid the enforcement of the quarantine laws.

(12) Finally, it is urged that growers carefully test such control measures as are here summarized as may seem most feasible or promising to them, and report their success, whether good, bad, or indifferent, that advice may be given against all unnecessary practices and a selection may be made of those which are the most essential for the destruction of the sweet-potato weevil wherever and whenever it may occur. In case of any other practices, also, reports are welcome.

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